APPENDIX D

SAMPLE SCREENING CALCULATIONS

D.1 SAMPLE CANCER SCREENING CALCULATION FOR DERMAL CONTAMINANTS IN WATER

The equations used in calculating the risk from dermal exposure for contaminants in water are summarized in Exhibit D-1. This example illustrates the steps used to calculate the clean-up level from dermal exposure to compounds in water given an acceptable risk of 10^{-6}. The default scenarios used in the calculations are (1) the adult 30 year exposure, and (2) an age-adjusted 30 year exposure incorporating a child bathing for 1 hour/event (RME value), once a day, 350 days/year for 6 years and an adult showering at 35 min/event (RME value), once a day, 350 days/year for 24 years. The general equations are presented for any compound, and the example gives the calculation for one compound in water with a cancer risk of 10^{-6}.

EXHIBIT D-1

SUMMARY OF DERMAL RISK ASSESSMENT PROCESS

Risk Assessment Process		**Cancer Risk**		**Hazard Index**	
Hazard ID		Section 2		Section 2	
Exposure Assessment	**Child or Adult**	**Water Dose**	**Soil Dose**	**Water Dose**	**Soil Dose**
		Section 3.1, Equations 3.1-3.4 Appendix A	Section 3.2, Equations 3.11/3.12	Section 3.1, Equations 3.1-3.4	Section 3.2, Equations 3.11/3.12
	Age-adjusted Child/Adult SFS_{ADJ}	See Note	Section 3.2.2.5 Equation 3.21	See Note	Section 3.2.2.5, Equation 3.21
Toxicity Assessment		Section 4, $SF_{ABS,}$ Equation 4.2		Section 4, RfD_{ABS}, Equation 4.3	
Risk Characterization		Section 5.1, Equation 5.1 DAD x SF_{ABS}		Section 5.1, Equation 5.2 DAD/RfD_{ABS}	
		Uncertainty Analysis Section 5.2			

Note: The calculations used in developing the screening tables in Appendix B (Exhibits B-3 and B-4) for the water pathway determined that

Procedures: Given a cancer risk level at 10^{-6}

1) For cancer risk, from Equation 5.1:

$$DAD = \frac{\text{Dermal cancer risk}}{SF_{ABS}} = \frac{(\text{Dermal cancer risk}) \times (ABS_{GI})}{SF_o} \quad \text{(D.1)}$$

2) For hazard quotient, from Equation 5.2:

$$DAD = \text{Dermal hazard quotient} \times RfD_{ABS}$$
$$= \text{Dermal hazard quotient} \times RfD_o \times ABS_{GI} \quad \text{(D.2)}$$

3) Evaluate DA_{event} from Equation 3.1

$$DA_{event} = \frac{DAD \times BW \times AT}{EV \times ED \times EF \times SA} \quad \text{(D.3)}$$

4) Evaluate permissible water concentration C_w:

For organics, from Equations 3.2 and 3.3:

$$\text{If } t_{event} \le t^*, \text{ then: } C_w = \frac{DA_{event}}{2 \times FA \times K_p \sqrt{\frac{6 \tau_{event} \times t_{event}}{\pi}}} \quad \text{(D.4)}$$

$$\text{If } t_{event} > t^*, \text{ then: } C_w = \frac{DA_{event}}{FA \times K_p \left[\frac{t_{event}}{1+B} + 2 \tau_{event} \left(\frac{1 + 3B + 3B^2}{(1+B)^2} \right) \right]} \quad \text{(D.5)}$$

For inorganics, from Equation 3.4

the adult receptor experiences the highest dermal dose. Therefore, the adult exposure scenario is recommended for screening purposes. However, if an age-adjusted exposure scenario for the dermal route is selected to be consistent with methods for determining the risk of other routes of exposure (e.g., oral), sample calculations are provided as guidance.

Parameter	Definition	Default - Child	Default - Adult
TRL	Target Risk Level (unitless)	10^{-6}	10^{-6}
BW	Body Weight (kg)	15	70
AT	Averaging Time (yr)	70	70
SF_{ABS}	Absorbed Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	chemical-specific	chemical-specific
ED	Exposure Duration (yr)	6	30
EV	Event Frequency (events/day)	1	1
EF	Exposure Frequency (days/yr)	350	350
FA	Fraction Absorbed (unitless)	chemical-specific	chemical-specific
$t_{event\text{-}RME}$	Event Duration (hr)	1 (bathing)	0.58 (showering)
SA	Surface Area (cm^2)	6,600	18,000
K_p	Permeability coefficient (cm/hr)	chemical-specific	chemical-specific
ABS_{GI}	Absorption Fraction (unitless)	chemical-specific	chemical-specific
J_{event}	Lag time per event (hr)	chemical-specific	chemical-specific
SF_o	Oral Cancer Slope Factor (mg/kg-day)	chemical-specific	chemical-specific
t*	Time to Reach Steady State (hr)	chemical-specific	chemical-specific
DAD	Dermal Absorbed Dose (mg/kg-day)	site-specific	site-specific
DAD_{event}	Absorbed Dose per Event (mg/cm^2-event)	site-specific	site-specific

Sample Calculations for Exposure to a Carcinogen in Water

Tetrachloroethylene (PCE)

SF_o =5.2x10^{-2} (mg/kg-d)$^{-1}$

K_p = 0.033 cm/hr

ABS_{GI} = 1

t* = 2.18 hr

J_{event} = 0.91 hr

t_{event} = 0.58 hr

FA= 1

Residential exposure scenarios

Using Equations D.1, D.3 and D.4 and default values presented:

Adult:

$$DA_{event} = DAD \times AT\left[\frac{BW_{adult}}{EV_a \times ED_a \times EF_a \times SA_a}\right] \qquad \text{(D.3)}$$

$$DA_{event} = (1.9\times10^{-5} mg/kg\text{-}day)\,(25550 day)\left[\frac{70 kg}{1\ event/day \times 30 yr \times 350 day/yr \times 18{,}000 cm^2}\right] = 1.8 \times 10^{-7}\ mg/cm^2\text{-}event$$

$$C_w = \frac{DA_{event}}{2 \times FA \times K_p \sqrt{\frac{6\,\tau_{event} \times t_{event}}{\pi}}} \qquad \text{(D.4)}$$

$$C_w = \frac{1.8\times10^{-7}\ mg/cm^2\text{-}event}{2\ (1)\ (0.033\ cm/hr)\sqrt{\frac{6 \times 0.91\ hr \times 0.58\ hr}{\pi}}} = 2.7 \times 10^{-6} mg/cm^3$$

$$C_w = 2.7 \times 10^{-6} mg/cm^3 = 2.7\ \mu g/L = 2.7\ ppb$$

Age-Adjusted:

$$DA_{event} = DAD \times AT\left[\frac{BW_{child}}{EV_c \times ED_c \times EF_c \times SA_c} + \frac{BW_{adult}}{EV_a \times ED_a \times EF_a \times SA_a}\right]$$

Note: age-adjusted t_{event} for 6 years as child and 24 years as adult.

$$t_{event} = \frac{(6\ year \times 1\ hr/event) + (24\ years \times 0.58\ hr/event)}{30\ years}$$

$$t_{event} = 0.66\ hr/event$$

$$DA_{event} = (1.9 \times 10^{-5} mg/kg\text{-}day)(25550 day)\left[\frac{15kg}{1\ event/day \times 6yr \times 350day/yr \times 6{,}600cm^2} + \frac{70kg}{1\ event/day \times 24yr \times 350day/yr \times 18{,}000cm^2}\right]$$

$$DA_{event} = 7.5 \times 10^{-7} mg/cm^2\text{-}event$$

$$C_w = \frac{7.5 \times 10^{-7}\ mg/cm^2\text{-}event}{2\ (1)\ (0.033\ cm/hr)\sqrt{\frac{6 \times 0.91\ hr \times 0.66\ hr}{\pi}}} = 1.1 \times 0^{-5} mg/cm^3$$

$$1.1 \times 10^{-5} mg/cm^3 = 11\ ug/L = 11\ ppb$$

D.2 SAMPLE NON-CANCER SCREENING CALCULATION FOR CONTAMINANTS IN RESIDENTIAL SOIL

The equations to be used in the determination of a dermal hazard index for residential soil contamination are outlined in Exhibit 5-1. This example uses cadmium in soil and calculates a level of concern that is equal to a hazard index of 1. Following the four steps of the risk assessment process.

Hazard ID: cadmium has both an oral reference dose and ABS_d to allow for a quantitative evaluation.

Exposure Assessment: the scenario to be evaluated is residential soil. Equations 3.11 and 3.12 are combined and solved for the soil concentration C_{soil} resulting in the following.

Example Dermal Calculations Using Child, Adult and Age-Adjusted Scenarios

Screening Level Equation for Dermal Contact with Non-carcinogenic Contaminants in Residential Soil

$$C_{soil} = \frac{THQ \times RfD \times BW \times AT \times 365\ days/yr \times 10^6\ mg/kg}{ED \times EV \times EF \times SA \times AF \times ABS_d}$$

Equation for use with age-adjusted parameters:

$$C_{soil} = \frac{THQ \times RfD \times AT \times 365\ days/yr \times 10^6\ mg/kg}{EV \times EF \times SFS_{adj} \times ABS_d}$$

Parameter	Definition	Default - Child	Default - Adult	Default - Age-Adjusted
THQ	Target Hazard Quotient (unitless)	1	1	1
BW	Body Weight (kg)	15	70	--
AT	Averaging Time (yr)	6	30	30
RfD	Reference Dose (mg/kg-day)	chemical-specific	chemical-specific	chemical-specific
ED	Exposure Duration (yr)	6	30	--
EV	Event Frequency (events/day)	1	1	1
EF	Exposure Frequency (days/yr)	350	350	350
SA	Surface Area (cm^2)	2800	5700	--
AF	Adherence Factor (mg/cm^2-event)	0.2	0.07	--
ABS	Absorption Fraction (unitless)	chemical-specific	chemical-specific	chemical-specific
SFS_{adj}	Age-Adjusted Dermal Factor (see equation below)	--	--	360

The age-adjusted, body-part weighted dermal factor is as presented in Section 3.2.2.5.

$$SFS_{adj} = \frac{(SA_{1-6}) \times (AF_{1-6}) \times (ED_{1-6})}{(BW_{1-6})} + \frac{(SA_{7-31}) \times (AF_{7-31}) \times (ED_{7-31})}{(BW_{7-31})}$$

$$SFS_{adj} = \frac{(2800 cm^2) \times (0.2 mg/cm^2\text{-}event) \times (6 yr)}{(15 kg)} + \frac{(5700 cm^2) \times (0.07 mg/cm^2\text{-}event) \times (24 yr)}{(70 kg)}$$

$$SFS_{adj} = 360\ mg\text{-}yrs/kg\text{-}event$$

The dermal absorption fraction for cadmium comes from Exhibit 3-4 and is 0.001.

Toxicity Assessment: In order to determine the dermal reference dose, data from Exhibit 4-1 suggests that the gastrointestinal adjustment for cadmium is either 5% for water or, more applicable for this example, 2.5% from food. Therefore, the dermal reference dose is 3E-5 (mg/kg-day) using Equation 4.3, the oral reference dose of 1E-3 from food, and a GI absorption of 2.5%. Note: since the pharmacokinetic model used to derive the oral RfD is based on human data and the differential absorption data between different media is taken into account, the dermal reference dose would be the same via either media, food or water.

$$RfD_{ABS} = RfD_o \times ABS_{GI}$$

$$(1 \times 10^{-3} mg/kg\text{-}day) \times (0.025) = 2.5 \times 10^{-5} mg/kg\text{-}day$$

Risk Characterization: Incorporating all the previous data results in the following:

Sample Calculations for Exposure to a Non-Carcinogen

Cadmium

Child:

$$C_{soil} = \frac{(1)\ x\ (0.000025\ mg/kg\text{-}day)\ x\ (15\ kg)\ x\ (6\ yr)\ x\ (365\ days/yr)\ x\ (10^6 mg/kg)}{(6\ yr)\ x\ (1\ event/day)\ x\ (350\ days/yr)\ x\ (2800\ cm^2)\ x\ (0.2\ mg/cm^2\text{-}event)\ x\ (0.001)}$$

$$C_{soil} = 700\ mg/kg = 700\ ppm$$

Adult:

$$C_{soil} = \frac{(1)\ x\ (0.000025\ mg/kg\text{-}day)\ x\ (70\ kg)\ x\ (30\ yr)\ x\ (365\ days/yr)\ x\ (10^6 mg/kg)}{(30\ yr)\ x\ (1\ event/day)\ x\ (350\ days/yr)\ x\ (5700\ cm^2)\ x\ (0.07\ mg/cm^2\text{-}event)\ x\ (0.001)}$$

$$C_{soil} = 4{,}600\ mg/kg = 4{,}600\ ppm$$

Age-Adjusted:

$$C_{soil} = \frac{(1)\ x\ (0.000025\ mg/kg\text{-}day)\ x\ (30\ yr)\ x\ (365\ days/yr)\ x\ (10^6 mg/kg)}{(1\ event/day)\ x\ (350\ days/yr)\ x\ (360\ mg\text{-}yr/kg\text{-}event)\ x\ (0.001)}$$

$$C_{soil} = 2{,}200\ mg/kg = 2{,}200\ ppm$$